

# The History of Gastric Surgery: the Contribution of the Belfast School

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## INTRODUCTION:

Many aspects of the colourful history of gastric surgery are familiar to most scholars of medicine: Theodor Billroth's first gastrectomy for cancer<sup>1</sup>, the attempts of Moynihan and Roux to develop procedures which would reduce the unwanted effects of gastrectomy for peptic ulcer<sup>2</sup>, the contributions of Pavlov and Latarjet to the understanding of gastric physiology and anatomy respectively<sup>3</sup>, Lester Dragstedt's application of this knowledge in performing the first therapeutic vagotomy for peptic ulcer<sup>4</sup>...each has been thoroughly documented in the annals of surgical history; and its associated anecdotes passed on by many a consultant surgeon to his trainees across the operating table. What is less well known is that the surgeons and physicians of Belfast also played a key role in the development of the art and science of gastric surgery, making several significant advances which will be highlighted by this paper.

## COLONEL AB MITCHELL: SUCCESS IN SURGICAL TREATMENT OF PERFORATED PEPTIC ULCER

In 1886, five years after Billroth's landmark operation, Professor Thomas Sinclair performed the first Belfast gastrectomy for cancer<sup>5</sup>. Subsequently, the General Hospital in Frederick St, which was the forerunner of today's Royal Victoria Hospital, became one of the first centres to demonstrate success in the surgical treatment of perforated ulcer. There, Sir John Campbell, a careful surgeon credited with introducing the wearing of rubber gloves in theatre in Northern Ireland, successfully closed his first perforation in 1897<sup>5</sup>. His colleague, Colonel AB Mitchell, operated on a second case in the same year and by 1903 had published a series of twelve such procedures<sup>6</sup>. While the first three ended unhappily because of a delay in diagnosis, the success of eight of the following nine was a considerable achievement in an era when surgical repair was discouraged by sceptical physicians except as a last resort. The antagonism felt by many prominent physicians towards surgical procedures on the stomach was even greater then than it is today. For example, in 1882, following Billroth's successful gastrectomy for cancer, Ludwig Rydygier in Poland reported the first gastrectomy for gastric ulcer. When the abstract was published in Germany later that year, the editor added the famous footnote "*Hoffentlich auch Letzte*" (hopefully also the last)<sup>7</sup>.

Mitchell persevered in spite of the relatively hostile climate. Further papers followed, including an educational brief concerning 'Perforated duodenal ulcer' which was published in the British Medical Journal and read at the BMA meeting in Belfast in 1909<sup>8</sup>. In this narrative, Mitchell emphasized the need for early diagnosis if surgery was to be successful, deriding the contemporary insistence on 'shock' as an indicator of perforation. '*How often are we told, "I do not think there is a perforation, there is no shock."*', he exclaimed, '*I wish this word shock had never appeared in our textbooks!*'<sup>8</sup>. For Mitchell, perforation was signified by the onset of rigidity, a sign he called the abdomen's '*trumpet call for help*'. He was acutely aware of the need to provide additional fluid for such patients, a phenomenon often called "third spacing" in contemporary medical parlance. He was therefore insistent on the need for continuous post-operative administration of saline per rectum, since intravenous fluid administration was not an option at that time: '*a nurse who understands the process and will not be satisfied unless she can get in at least one pint per hour is essential!*'<sup>8</sup>

Mitchell's final paper, giving results of 110 operations for gastric and duodenal ulcer followed in 1911. These were not excelled by any other surgeon of the time and brought great acclaim to the Belfast School of Surgery<sup>6</sup>. Mitchell's achievements are particularly admirable when it is considered that he was working long before the advent of antibiotics or intravenous fluid administration, and it is fitting that his contribution is commemorated annually in the AB Mitchell memorial lecture.

If Mitchell had shown that operative treatment could be effective in compromised patients with perforated ulcers, it seemed reasonable to assume that surgery would be even more successful if used to prevent perforation in patients with uncomplicated ulcer disease. Resectional procedures became commonplace but the results were not as pleasing as expected: since these patients had benign disease, they survived for long enough for the side effects – vomiting and diarrhoea, the 'dumping syndrome' and nutritional disturbances – to become

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a serious drawback. Indeed, a leading gastric surgeon of the time once exclaimed, *'If anyone wanted to cut out half of my good stomach in order to cure a little ulcer in my duodenum, I would run faster than he!'*<sup>9</sup> Empirical experimentation with mechanical modifications – led by figures such as Moynihan, Roux and JP Finney, a surgeon of Ulster descent who was the first Resident Surgeon at the celebrated Johns Hopkins Hospital – led to some improvement, but it was parallel advances in the field of gastric physiology which would ultimately revolutionize peptic ulcer treatment.

### JC ADAMS: LINKING HYPERACIDITY AND ULCERATION

As early as 1833, William Beaumont had demonstrated the presence of hydrochloric acid in the juices discharged from his patient's gastro-cutaneous fistula<sup>10</sup>. In 1910, Schwarz coined the aphorism *'no acid, no ulcer'*, based on his clinical observation that ulceration only occurred where gastric juice exerted its influence<sup>9</sup>. The definitive demonstration of a link between hyperacidity and duodenal ulceration is often attributed to Lord Moynihan; however, Moynihan himself credited the 1911 MD thesis of James C Adams of Belfast<sup>11</sup>.

Adams was the son of a County Antrim farmer, a *'large, straight and rather stern man'* who graduated from Queen's University in 1894. He became a general practitioner at 212 Ravenhill Road, a post he retained until his death in 1951, and took no time off, conducting his research in the evenings<sup>11</sup>. Between 1905 and 1911 he studied twenty patients with duodenal ulcer using Ewald test meals and found that fourteen of them had hyperchlorhydria. This result was the basis for Moynihan's oft-quoted maxim that hyperacidity was a factor in 70% of duodenal ulcers<sup>4</sup>. Adams concluded, *'Hyperchlorhydria...is a condition of congestion, hyperaesthesia and hyperacidity...with intervals between attacks...It might be that after this condition had existed for some length of time an ulcer formed.'* He also noted another common consequence of hyperacidity, the *'continuous and copious flow of saliva which is very distressing to the patient'*<sup>11</sup>. It is unfortunate that Adams, a modest man, published no more of his research, but his dedication to medicine inspired many of his family to follow him into the profession<sup>11</sup>.

If hyperacidity was an aetiological factor in peptic ulceration, it was logical for surgeons to seek a means of reducing acid secretion for therapeutic purposes. Their way had been paved by nineteenth-century physiologists who had largely elucidated the mechanism of gastric secretion. It was Ivan Pavlov who provided the first definitive evidence of the role of the vagus nerves in this process: His classic experiment demonstrated that, following the administration of a 'sham feed', gastric juice was produced in the empty stomachs of dogs with diverted oesophagi, but that this secretion was reduced after the dogs had been subjected to vagotomy<sup>3</sup>.

In 1924, a French surgeon, Latarjet, published the first results of a series of vagotomies for the treatment of peptic ulcer in humans. However, he had added a gastro-jejunostomy in the latter patients, and many observers attributed his success to this procedure rather than the vagotomy itself<sup>3</sup>. It was not until the 1940s, when Lester Dragstedt arrived on the international stage of gastric surgery, that vagotomy became

accepted as a mainstay of ulcer treatment. A rigorous scientist, Dragstedt believed that surgical treatment should be *'simple, straightforward and deal with the pathophysiologic root of the disease'*<sup>12</sup>, and demonstrated that vagotomy fulfilled these criteria, performing no less than 158 such operations himself.

Even vagotomy was not without complications, however: bile vomiting, diarrhoea and dumping were all problematical, leaving Pollock to conclude in a 1952 Lancet review article that; *'Fashions in the treatment of peptic ulcer come and go, and the surgical problem remains unsolved'*<sup>3</sup>. Nevertheless, by the late 1950s, refinements in the technique and the combined use of vagotomy with more traditional procedures led to the publication of more favourable outcomes.

In the following decade, selective vagotomy, as first performed by Griffith and Harkins, also gained a following, the rationale being that preservation of vagal branches other than those supplying the stomach would reduce the side-effects of the surgery. A prominent Belfast surgeon, Terence Kennedy aptly summarized the dilemma, albeit with a rather quaint analogy: *'No surgeon wishing to denervate the soleus muscle for intermittent claudication would divide the sciatic nerve in the thigh; yet most surgeons using vagotomy for duodenal ulcer unthinkingly divide the whole of the vagus nerves immediately below the diaphragm, thus dividing all abdominal viscera, except the distal colon, of their para-sympathetic supply.'*<sup>3</sup> At the same time John Goligher (1912-98), an Ulsterman working in Leeds, suggested that a 'belt and braces' approach, using truncal vagotomy to reduce neural acid stimulation combined with antrectomy to reduce hormonal stimuli, was the optimum procedure<sup>13</sup>. Goligher was appointed to the chair of surgery in Leeds in 1955, a post he held until 1978, and, although his major surgical interest was in colon surgery, he nevertheless contributed hugely to the field of gastric surgery by creating an academic environment in which young surgeons could develop expertise as surgeon-investigators.

### THE BELFAST TRIALS: KENNEDY LEADS THE WAY ON THE ROAD TO RATIONALISATION

By the mid-1960s, then, there were two major varieties of denervation and at least eight drainage procedures being performed in the treatment of duodenal ulcer, but little consensus as to which combination produced the best results. This situation was considered highly unsatisfactory by Terence Kennedy, who believed that surgeons were submitting patients to unnecessary and crippling side-effects (Figure 1). In Kennedy's opinion, every patient had the right to the operation with the lowest mortality, the least physiological disturbance, a recurrence rate of less than 5% and the option of reversibility should unforeseen complications occur<sup>14</sup>. Like Billroth, Pavlov and Dragstedt before him, Kennedy was a true devotee of rigorous scientific pursuit of facts and was one of the earliest advocates of the use of randomized, double-blind, controlled trials in surgery. He was scornful of those *'Olympians of the surgical stage'*, such as Lord Moynihan, whose pronouncements regarding ulcer treatment were widely accepted on the grounds of his personal charisma and eminence, rather than on the basis of any objective evidence. Kennedy was also critical of the early trials of Goligher and Kraft, pointing to the heterogeneity of their material, absence of randomization and incomplete follow-up<sup>15</sup>.



Thus, together with a newly appointed colleague, George Johnston (Figure 2), and physician Dr Alistair Connell, Kennedy set out on a crusade to provide evidence which would rationalize the treatment of duodenal ulcer and improve the fortunes of patients worldwide. He began in 1966-7 with a trial designed to test claims that selective vagotomy produced less side-effects than truncal vagotomy, particularly where diarrhoea was concerned<sup>16</sup>. This was conducted by his own surgical team only in order to ensure that *'the techniques would be uniform and the data...more reliable'*<sup>15</sup>, with 100 patients randomized to receive either truncal vagotomy or selective vagotomy, both with Finney pyloroplasty, and with the follow-up assessment performed by a physician unaware of which treatment the patients had received. At both the 2-year and 5-year follow-up stages there was significantly less diarrhoea in the selective vagotomy group, as well as a trend towards reduced recurrence rates, apparently verifying the suggestion that selective vagotomy was superior to the truncal procedure. As Johnston neatly put it, *'When we boil it down to the number of times patients require to go to the toilet...patients with truncal vagotomy went about five times as often as those with selective vagotomy'*<sup>17</sup>, a consideration less likely to be overlooked by a patient than the surgeon.

However, the problems of dumping and bile vomiting still remained. This was attributed to "gastric incontinence" a term coined by another Belfast surgeon, Samuel McKelvey. Kennedy therefore decided to establish which drainage procedure would minimize these side-effects, challenging the widely held but unsubstantiated belief that pyloroplasty was superior to gastrojejunostomy. A further randomized controlled trial was commenced in 1968, with patients receiving selective vagotomy in combination with either of the above<sup>18</sup>. At 3.5

year follow-up there were no significant differences between the two groups but the patients with gastrojejunostomy were more satisfied and had a lower recurrence rate: further, unlike a pyloroplasty, a gastrojejunostomy could be reversed if the side-effects were intolerable. In this sense, it was noted that *'if gastrojejunostomy is a disease then pyloroplasty is an incurable disease!'*<sup>5</sup>.

In the meantime, Amdrup in Copenhagen and David Johnston of Leeds simultaneously described the use of 'highly selective' or 'proximal gastric' vagotomy, in which the innervation of the antral pump was left intact so that normal gastric emptying could be maintained, obviating the need for a drainage procedure<sup>3</sup>. To establish if this method was as effective as selective vagotomy with gastrojejunostomy, and whether there was any real improvement in patient satisfaction, Kennedy and Johnston commenced a third major randomized controlled trial in 1970. This demonstrated that dumping, bile vomiting and diarrhoea were virtually eliminated by the new Highly Selective Vagotomy (HSV), but that recurrence rates were significantly greater at 12% compared with 4% in selective vagotomy<sup>19</sup>. When the team published a long term follow-up study of 600 patients who had undergone HSV in 1990, however, the great majority of the 11% who had experienced recurrence had achieved control with medication, while overall 92% were satisfied (Visick grade I or II), an excellent result in light of the fact that the figure for the 'normal' population is 93%<sup>20</sup>. The same team was quick to recognize an important but rare complication of highly selective vagotomy, namely lesser curve necrosis, which in the Belfast series only occurred when HSV was combined with Nissen fundoplication, highlighting the important risk of creating ischaemia of the upper stomach.



Figure 1: Mr Terence Kennedy

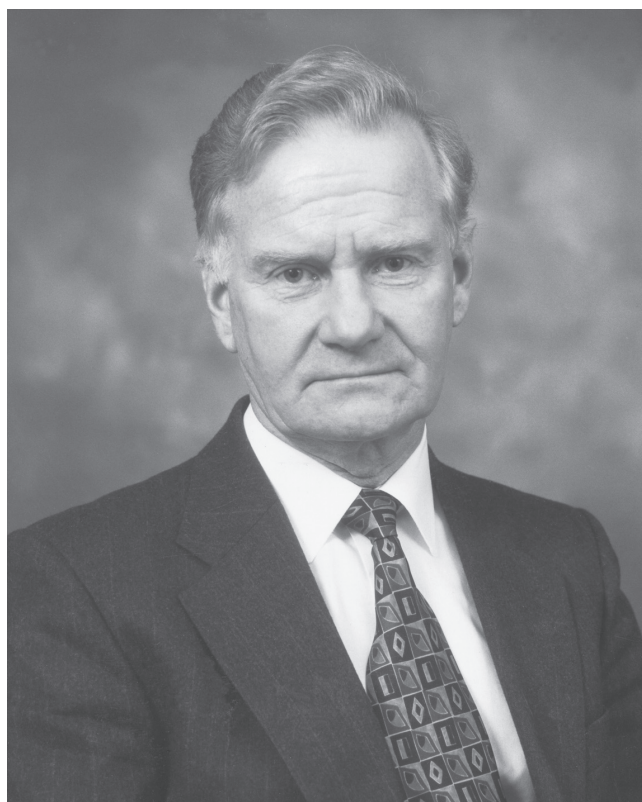


Figure 2: Professor George Johnston

In conjunction with these central trials, Kennedy and his team conducted a variety of experiments into the physiology behind their results. They published papers on the role of gastric emptying, intestinal transit time, pancreatic and biliary dysfunction and coeliac and hepatic nerve conduction in the development of 'post-vagotomy syndrome', defined the role of the duodenum in gastrin release, described changes in antral motility after proximal gastric vagotomy and identified changes in intestinal flora after a range of anti-ulcer procedures<sup>21-7</sup>. They investigated the post-operative nutritional status of their patients in detail<sup>28</sup> and defined the place of vagotomy in the treatment of gastric ulcer with results confirming that such a procedure, previously avoided by many surgeons, was indeed satisfactory in gastric ulcers of types II and III. For type I ulcers, however, with no duodenal or antral component, it was advised that partial gastrectomy should still be carried out because of the substantial risk of malignancy<sup>29</sup>.

Thus, by the early 1970s, these Belfast trials had provided clear answers to some of the key questions surrounding the issue of vagotomy, thanks in no small measure to the determination and character of the men concerned. Temperamentally they were very different: Kennedy was a tall and intimidating Englishman with socialist political views and a quick temper, while Johnston was a local man of short stature with a ready wit and deep Christian convictions, but they got on extremely well and developed a deep mutual respect<sup>30</sup>. As Johnston said of his 'sparring partner' with characteristic humour, *'It was great to work with a colleague to whom one could look up, not only literally but metaphorically!'*<sup>31</sup>. There is no doubt that both were extremely kind and gentle with their patients and staff, indeed Sr. Fiona Cherry on Wards 15 and 16 where he worked insisted, with some orthographic license, that the initials TLK stood for 'tender loving care'. The other characteristic which defined both surgeons was their integrity and transparency in their work and research.

One remarkable feature of their trials was the high percentage of patients followed up. This was no mean feat as the civil unrest in Northern Ireland was at its height and fear of travelling to West Belfast made patients reluctant to visit the Royal Victoria Hospital. Undeterred, Kennedy's research assistant Dr Anne Spencer would set off on foot or by car with her phlebotomy kit to visit each one at home, sometimes having to find out new addresses from neighbours if a patient had moved on. On a number of occasions when Dr Spencer had to visit a particularly dangerous area, and when she followed up patients in the security wing of Musgrave Park Hospital, Kennedy made time to accompany her personally. In one trial 99 of the 100 patients had been charted but one patient, a twenty year old man, remained elusive. It later emerged that he had been carrying a bomb into the centre of Belfast when it exploded prematurely, killing him<sup>30</sup>!

The contributions of Kennedy and Johnston led to international acclaim and they traveled extensively to present their findings, both being invited as visiting professors to prestigious universities in North America. Kennedy in particular wrote numerous educational articles on peptic ulceration<sup>14, 32-5</sup> and was honoured with many teaching opportunities, including the invitation to deliver the first Graham Coupland memorial lecture in Sydney, Australia and becoming one of few local

physicians to be asked to deliver the Scott-Heron Lecture in his own hospital. His ability to communicate with colleagues, combined with his pioneering research, led to his election as President of the Association of Surgeons of Great Britain and Ireland in 1980-81, the same year George Johnston was elected secretary. Consequently, the Association Annual Meeting was held in Belfast in April 1981, an occasion which marked the zenith of Kennedy's career and perhaps of the Belfast school of gastrointestinal surgery<sup>36</sup>.

By 1981, the basis and indications for vagotomy in its various forms had been firmly established and the debate at the meeting surrounded the management of those 10% of patients who suffered recurrent ulceration after surgery. The mid-1970s had seen the introduction of histamine receptor antagonists, notably Cimetidine, as a potential alternative to re-operation in such cases. Indeed, Kennedy, alert as always to new possibilities in optimum patient management, had conducted a randomized trial of Cimetidine versus placebo in 1978 but had found no significant differences in ulcer healing, pain or antacid consumption<sup>37</sup>. It appeared that, for the time being at least, a surgical solution to the problem was still important.

As part of the annual meeting of the Association of Surgeons, a special 'Billroth Symposium' was held to commemorate the centenary of the first successful gastrectomy. This was a grand occasion in the Whitla Hall at Queen's University, at which 400 delegates attended<sup>36</sup>. Aires Barros D'Sa, then a young vascular surgeon in the Royal Victoria Hospital, arranged for the two string quartets dedicated to Billroth by Johannes Brahms (op 51 no 1&2) to be played in the background. This artistic subtlety went completely unnoticed by the audience. It was nevertheless a fitting tribute to a man whose name had been immortalized not only through Brahms' music, but also through his own legacy of surgical innovation. It was appropriate that tribute could be paid to Billroth in Kennedy's adopted home city during a short window of peaceful opportunity. A few weeks later, the death of the hunger striker Bobby Sands and the subsequent escalation of violence in the Province would have rendered any such international meeting there unthinkable.

In that same year, Kennedy was awarded an Honorary MD from Queen's University and was elected to the Council of the Royal College of Surgeons of England. He continued his dynamic partnership with Johnston until his retirement in 1984, true as ever to his lifelong motto, 'Don't let the grass grow under your feet', or the Latin equivalent, '*Carpe Diem*' which was displayed in Wards 15 and 16 until their demolition in 2003<sup>31</sup>. On his last working day he performed a full theatre list as usual, quietly inscribing the word '*fini*' at the bottom of the final operation report<sup>30</sup>. He chose never to speak in public again as he firmly believed that medical knowledge became out of date within a day, preferring to spend his last years pursuing his interests in sailing and gardening.

### A REQUIEM FOR VAGOTOMY

On the other hand, Johnston continued his work in gastric surgery while pursuing his other major interest in the management of portal hypertension<sup>38</sup>. The 1980s proved to be a significant era of change where the treatment of peptic ulceration was concerned: First of all, pharmacological therapy



became more attractive as the powerful proton pump inhibitors (PPIs) were added to the physician's armamentarium. Then, Barry Marshall's revolutionary discovery of the ulcerogenic properties of *Helicobacter pylori* opened up the possibility of curing the underlying disease through an eradication regime combining Omeprazole with two antibiotics, an intervention shown to induce ulcer healing in 90% of patients<sup>5</sup>.

Parallel to these changes in ulcer treatment, the true incidence of peptic ulceration was also shown to be declining, a phenomenon most likely due to the falling incidence of *H pylori* in the community<sup>39</sup>. The halcyon days of surgery for ulcer appeared to be over, prompting Professor J Alexander-Williams to publish his '*Requiem for Vagotomy*' in the British Medical Journal in 1991<sup>40</sup>. Johnston and his colleagues were not convinced, however, and composed a vigorous reply pointing to the fact that, while elective ulcer surgery had indeed declined, the number of emergency admissions for complications had remained almost constant<sup>41</sup>. They also suggested that long-term drug therapy invited poor compliance and gave less satisfactory Visick gradings, as well as highlighting evidence that up to 50% of medically-treated patients would require surgery at some point. Their reply concluded with the emphatic statement, '*Proximal gastric vagotomy is not dead and should not be buried.*'

However, by 1994 ulcer surgery truly was almost extinct: Professor Johnston performed only three vagotomies in his last working year. Throughout the 1980s a similar decline in cases of gastric cancer was observed, probably because it similarly was shown to be related to infection with *Helicobacter*. Epidemiological studies from many Westernised countries showed the incidence of gastric cancer to be declining steadily<sup>39</sup>. One could be forgiven for supposing that the time had come for gastric surgeons to relinquish their scalpels and seek new occupational horizons. However, just as quickly as ulceration declined, two other diseases became more amenable to surgical treatment, in the wake of the laparoscopic revolution.

### NEW DISEASES; NEW CHALLENGES FOR GASTRIC SURGEONS

The number of cases of gastro-oesophageal reflux disease (GORD) started to rise exponentially – in Belfast as elsewhere – just as peptic ulcer surgery began its dramatic decline. It is paradoxical that these two diseases appeared to be inversely related when it is considered that both are associated with acid secretion, the pharmacological control of which had never been better. A number of prominent surgeons, notably Tom DeMeester in the USA, began to investigate the pathophysiology of GORD. They discovered that 60% of GORD patients had an incompetent lower oesophageal sphincter<sup>42</sup>, a mechanical problem which would not respond to pharmacological acid suppression but which was potentially remediable through surgical intervention. Over the next few years, a variety of 'fundoplication' procedures were developed which were intended to restore sphincter function. In 1986, DeMeester published a report showing one such operation to be 91% effective in the control of reflux symptoms over a 10 year period, a success rate superior to that of any medical therapy<sup>43</sup>. Shortly afterwards, the introduction of laparoscopic surgery led to the development of laparoscopic Nissen fundoplication, an operation now well established in the

armamentarium of all upper gastrointestinal surgeons, despite the enormous consumption of Proton Pump Inhibitors.

The second of the two diseases, morbid obesity, is only now gaining recognition as a surgical problem in the UK, and bariatric (anti-obesity) procedures have yet to be carried out in Belfast. In the United States, however, bariatric procedures have grown in popularity to such an extent that they have come to be described, with some irony, as the gastric surgeon's bread and butter. Some interesting parallels can be drawn between the understanding of morbid obesity and GORD: both were not initially considered to be a disease, lifestyle alterations were advocated in both conditions with little success, and medical therapies, including appetite suppressants and lipase inhibitors in the case of morbid obesity, were introduced with little effect on the growing scale of either problem. Finally, the introduction of a low risk and highly effective laparoscopic operation for both diseases led to its widespread adoption.

The earliest operations for morbid obesity did not involve the stomach at all, but were designed to bypass the small bowel. Their dangerous side effects, including liver failure, renal calculi, and extreme diarrhea, made them too hazardous to gain widespread acceptance. Surgeons then explored the possibility of restricting oral intake by operating on the stomach. Edward Mason of Iowa developed Vertical Banded Gastroplasty in the early 1970s, and though it avoided the mortality associated with intestinal bypass procedures, it was less effective and often caused refractory vomiting<sup>44</sup>. Many other surgeons experimented with different forms of gastric restriction, aided by the co-incidental introduction of surgical stapling into routine operative techniques. Purely restrictive procedures did not produce reliable and symptom free weight loss until the development of the adjustable gastric band, initially in Sweden<sup>45</sup>. Nowadays, the most common operations performed for morbid obesity are the Roux Y Gastric Bypass and the so-called "lap band"<sup>46</sup>. Thanks in part to the legacy of Terence Kennedy, it is now generally accepted that such innovations must be subjected to careful scrutiny by long-term follow up, and that competing treatments must be subjected to rigorous clinical trials, ensuring that clinicians and patients alike can be sure of their validity. Given the inexorable adoption into Ulster society of patterns of eating and exercise typical of those in North America, the introduction of bariatric surgery into Northern Ireland is unlikely to be far away.

### CONCLUSION

Perhaps public health measures such as 'fat taxes' and weight-based airline fares will help reduce the problem of obesity; perhaps a new pharmaceutical advance will restore a damaged Lower Oesophageal Sphincter. In either unlikely scenario it is doubtful that gastric surgeons will end up in the dole queue, for eating is one of the fundamental human activities, not just because of its nutritional function, but as the vehicle for social interactions from births and christenings to weddings, graduations, business deals, and even funerals. As Lester Dragstedt is alleged to have said, "*The stomach is a nice organ to take to dinner*", and it is likely that gastric surgeons worldwide will continue to be needed to ensure that the stomach fulfils its role, and to provide an effective substitute if the stomach has to be removed. The medical community in Ulster can be justifiably proud of the past accomplishments of its leading surgeons in this area, and we can expect equally

significant advances from their surgical sons – and daughters – in the future.

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